INVESTIGATIONS ON THE AREAL DISTRIBUTION OF SURFACE ALBEDO IN HUNGARY

by

Z. DOBOSI

Department of Meteorology, Eötvös University, Budapest
Received: 15 March, 1975

ZUSAMMENFASSUNG

Es wird die Möglichkeit der Berechnung und Benutzung einer durchschnittlichen Albedo erörtert und festgestellt, dass in Ungarn die Albedo keinen Zusammenhang – abgesehen vom Februar – mit der globalen Strahlung zeigt, so dass eine Durchschnittsbildung zugelassen werden kann. Für Februar, die Anbringung einer Korrektion soll gesichert sein.

Unter Benutzung von Messresultaten gewonnen in Ungarn und in anderen Ländern wird die territoriale Verteilung der Albedo der Oberfläche in Ungarn an mehreren Abbildungen dargestellt.

In climatology the albedo (A) is defined as quotient of the global radiation reflected by the surface (R) and of the incoming value (G) as follows:

$$A = \frac{R}{G}.$$

It is our aim to determine the areal distribution of the monthly mean value of the surface albedo. The value of the albedo is one of the important characteristics of the surface from meteorological point of view; its knowledge is needed for the calculation of that part of the irradiated energy of the sun which is actually absorbed by the surface and transformed into heat, respectively into latent heat. The absorptivity of the surface (E) and the albedo are connected with one another by the formula

$$E = 1 - A.$$

1. Computation of monthly averages of albedo

In what follows we show [D o b o s i 1961] that monthly averages of albedo are to be used in our calculations only in case there is no connection between the value of the albedo and that of the intensity of global radiation in the given month, as it will be obvious from the ensuing calculation. At Erdőhát nearly half of the days of January are days with snow cover. Assuming the value 0,18 for the albedo of the uncovered surface and 0.64 for the mean albedo value of the snow cover we obtain for the January average of the albedo the value : 0.41. The average value of the global radiation at Erdőhát is 3.1 kcal/cm^2 in this month. The reflected radiation computed using the albedo average is: $0.41 \cdot 3.1 = 1{,}27$ kcal/cm^2/month. If we assume the existence of such a connection between snow cover and global radiation that days with snow cover show a clear sky, while those without snow cover are overcast, and if we take into account for the clear days radiation sums as high a value as 190 cal/cm^2, while for the overcast days we use the value of 20 cal/cm^2, then we obtain for the monthly sum of the reflected radiation the value: 2,0 kcal/cm^2. On the other hand, if we assume a reversed connection, i.e. we suppose the days with snow cover to be overcast and those without a snow cover as clear ones, then the monthly reflected radiation will take the value : 0,7 kcal/cm^2.

Of course we can not suppose in reality the existence of such an extremely strong connection between state of ground and global radiation. Nevertheless it is possible that we can find such climatic regions, where there is some connection between the albedo of the surface and the intensity of the global radiation. The existence of such a connection can be supposed even in summer: it may happen that the wet state of ground – producing a small value of the albedo – is more frequent in case of overcast skies than during clear weather situations.

In case there is a connection between the albedo and the global radiation – as we saw it in our supposed example above – the albedo can not be averaged. In order to state, whether there exists a connection between the two climatic characteristics in our climatic region we computed correlation coefficients for Erdőhát between the albedo calculated from the state of the ground and the radiation sum of the day involved from data of the years 1951–1960.

We assumed that the following albedo values correspond to the state of ground values figuring in the calculations:

dry ground	0.18
wet ground	0.12
snow cover	0.64
snow patches	0.41,

The correlation coefficients obtained are:

I	II	III	IV	V	VI
−0.05	−0.24	0.07	0.01	−0.06	0.02
VII	VIII	IX	X	XI	XII
−0,07	0.07	0.09	0.05	−0.02	0.10

The highest random value belonging to the values of the table at the 5% level is $r' = 0{,}11$. We see that only the February value deviates significantly from zero, that of December is approaching only the said value. The February correlation value is supposedly the consequence of the fact that the average date of disappearing of the snow cover is the 24th of February. In that month the altitude of the sun is increasing rapidly, so that the decrease of the surface albedo owing to the disappearence of the snow cover becomes connected with an increase of radiation. In December the frequency of snow cover increases, thus the average albedo of the surface increases too. The absence of the expected negative correlation is probably brought about by the overcast character of the month, and the fact that the altitude of the sun decreases in the first half of December does not change even towards the end of the month significantly. The effect of the albedo change in connection with the beginning and the end of the vegetation period does not present itself in the data, because the albedo of the green vegetation does not deviate in a perceptible manner from that of the uncovered surface.

Thus, in our climate we can use the monthly albedo averages – except for February – for the calculations of monthly sums of the reflected, respectively absorbed radiation. The error made by the use of the average albedo values in February can be corrected by applying a difference-term, which is for Erdőhát given by the formula:

$$\overline{A} - \frac{A_i - G_i}{G_i} = 0{,}01 \,.$$

Here $\overline{A}$ denotes the average albedo for February, A_i and G_i are the albedo-respectively global radiation – values of the individual days. In what follows we applied this correction to the February albedos, though this correction is rather of a theoretical importance only owing to the accuracy of the albedo measurements.

2. The basic map of vegetation

The albedo is such a characteristic of the surface, which does not depend only on natural conditions. The interference of man modifies the surface through the ways of agricultural use and cultivation.

Our aim is to construct albedo maps reflecting not a momentary state, but the average conditions of a longer period.

We can assume that the surface of Hungary is covered with vegetation during the growth period. From this state there is a deviation only in the winter season, respectively in the case of ploughed surfaces. Since the albedo of forests – especially of those containing pines – significantly deviates from that of the other areas, first of all we need a map showing the measure of afforestation, giving for the single regions the ratio of afforestation as well as its aspects. The average albedos of agricultural

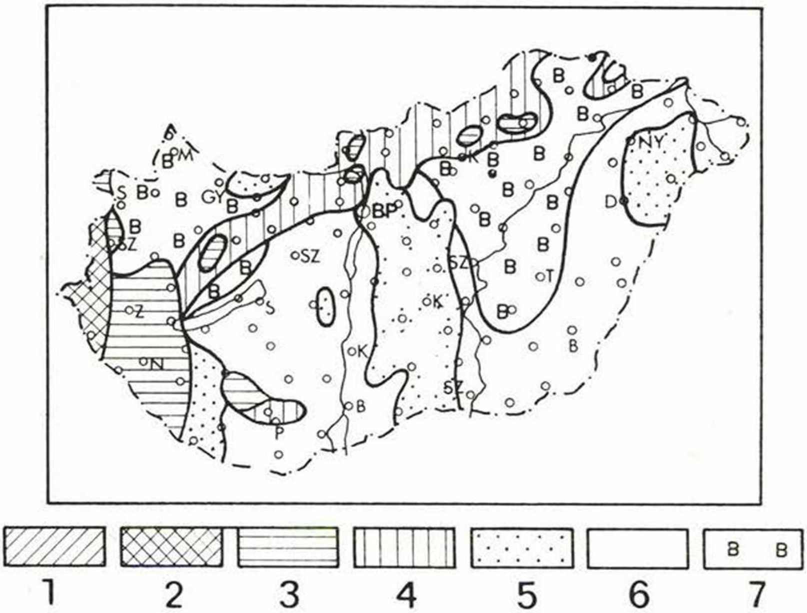

Fig. 1. Distribution of substrata taken into account in albedo determinations. 1. pines, 2. mixed pines, 3. beeches, 4. oaks, 5. agricultural sandy areas, 6. agricultural areas, 7. $3^2/_3$ cornfields (according to Borhidi)

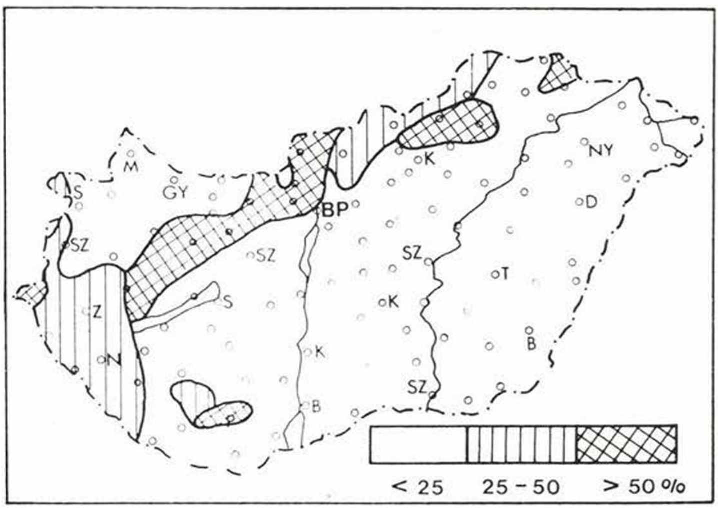

Fig. 2. Amount of afforestation

plant-stocks do not show significant deviations one from another [W e i n g a r t n e r 1968], though there appear differences in the various growth-phases. Thus it is practical tc denote such areas, where the ratio of wheat is greater than the average. It is also necessary to mark the sandy soil owing to the somewhat higher albedo-value of the sand. All these aspects are taken into account in a most satisfactory manner by the vegetation- and afforestation- maps of B o r h i d i [1967] prepared exclusively for the construction of albedo charts. (Fig. 1. and 2.). We accepted these as a base for our present albedo maps.

The representation of grass-lands on the map in case of the given scale was not possible owing to their small dimension. By the way, the albedo of grass-lands is nearly the same as that of corns and of the most important fodder plants according to the investigations of *W e i n g a r t-n e r* [1968]. We had also to disregard displaying saline soil owing to the scale used.

Our aim was that the vegatation map serving for base for albedo distribution display should separate the most important areas, for which albedo values can be determined with a practically constant validity in time.

3. Observation material used for the albedo determinations

Data of the reference literature regarding measurements abroad are rather deviating one from another even in case of an identical plant-stock too. Thus they represent only approximations for us and may be used in cases only where data of our own land are not at our disposal. Here, a progress was achieved by the observations of Weingartner made at Szarvas, who has measured for several years the albedo values of agricultural plants cultivated in our land. He computed not only average albedo values, but he gave data also for the various phases of development of the individual plants.

The albedo-maps [W e i n g a r t n e r 1970] of Weingartner has been prepared on the basis of his own measurements. Since he prepared his maps according to the same principles we applied [B o r h i d i and D o b o s i 1967], using the same vegetation – and afforestation – map for the months during which the surface is overwhelmingly covered by living vegetation (April to October), we accepted his maps, based on albedo observations made in Hungary, instead of our earlier maps based mostly on foreign data. In the interval November to March, when the frequency of snow cover [P é c z e l y 1966], the dry or wet state of the uncovered ground etc., i.e. the general state of ground play an important role, we used for the preparation of our maps [B o r h i d i and D o b o s i 1967] – besides the earlier data – also the paper of Mrs Adámi containing a study of ground state frequencies [A d á m i 1970] giving a rather detailed information for the whole area of Hungary.

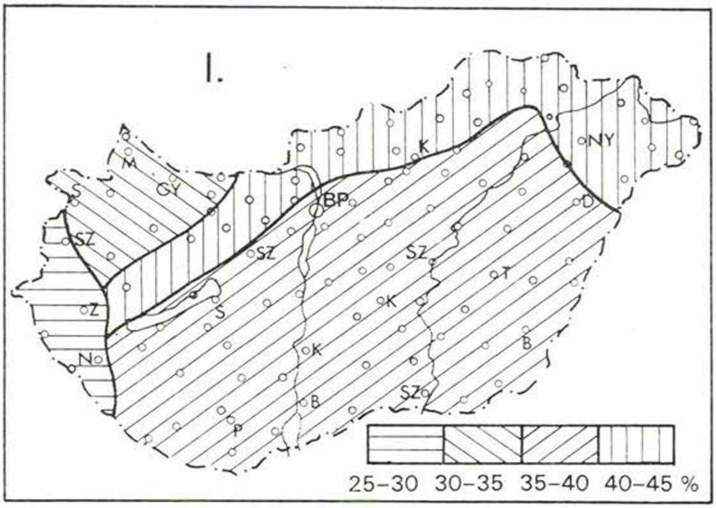

Fig. 3. Areal distribution of the albedo in January

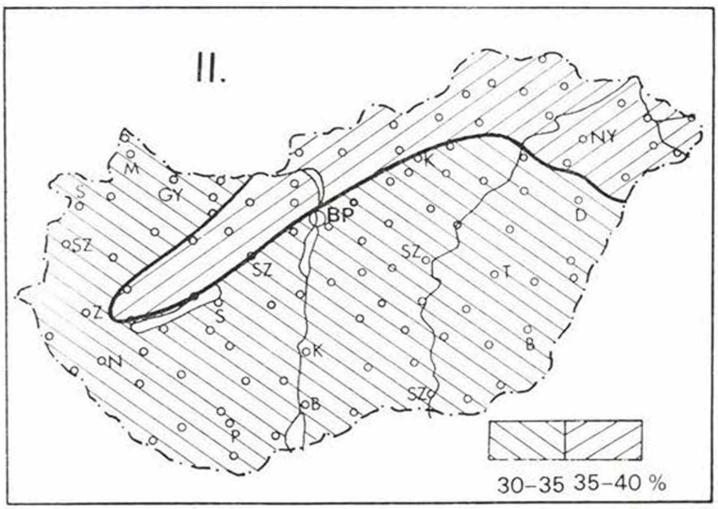

Fig. 4. Areal distribution of the albedo in February

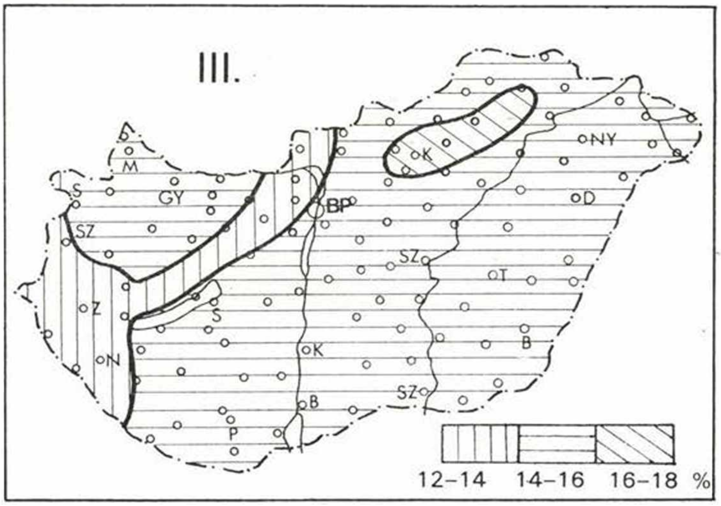

Fig. 5. Areal distribution of the albedo in March

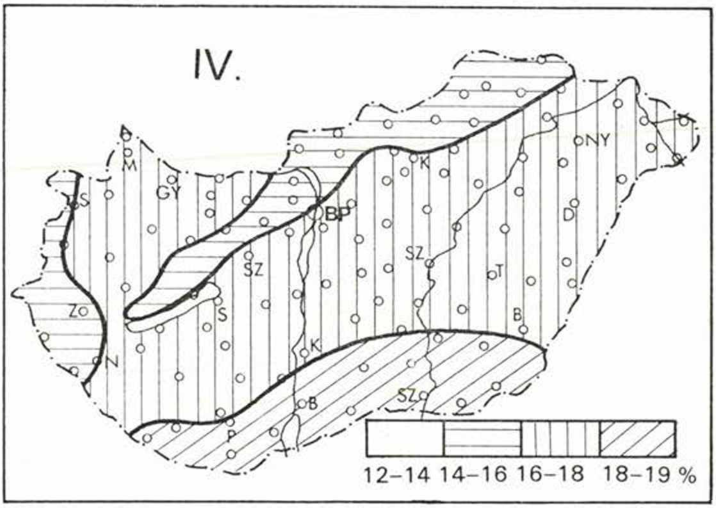

Fig. 6. Areal distribution of the albedo in April (after Weingartner)

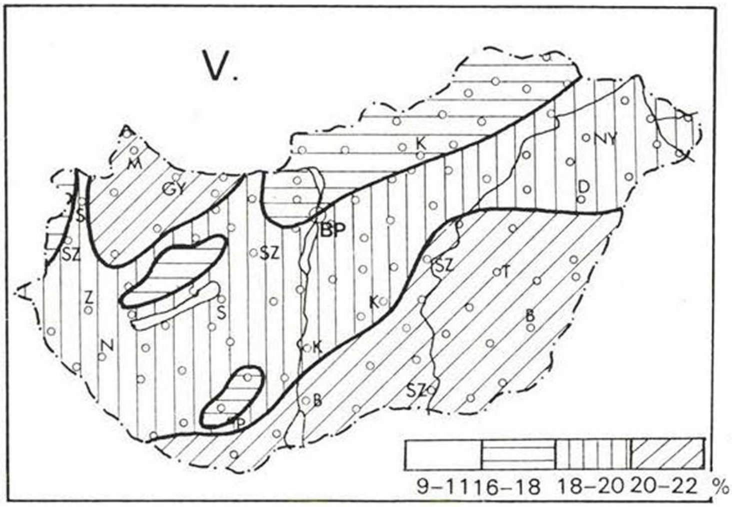

Fig. 7. Areal distribution of the albedo in Mai (after Weingartner)

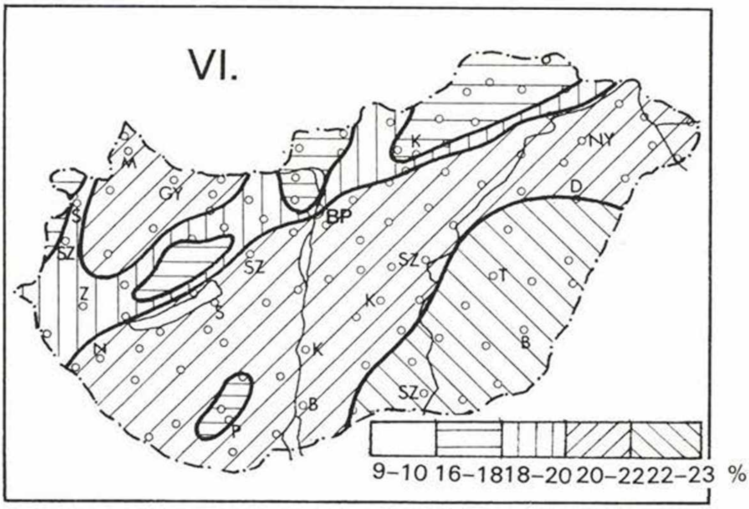

Fig. 8. Areal distribution of the albedo in June (after Weingartner)

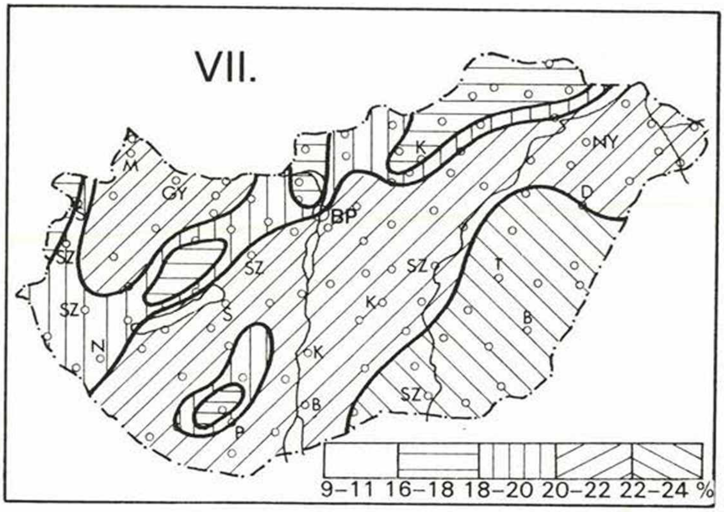

Fig. 9. Areal distribution of the albedo in July (after Weingartner)

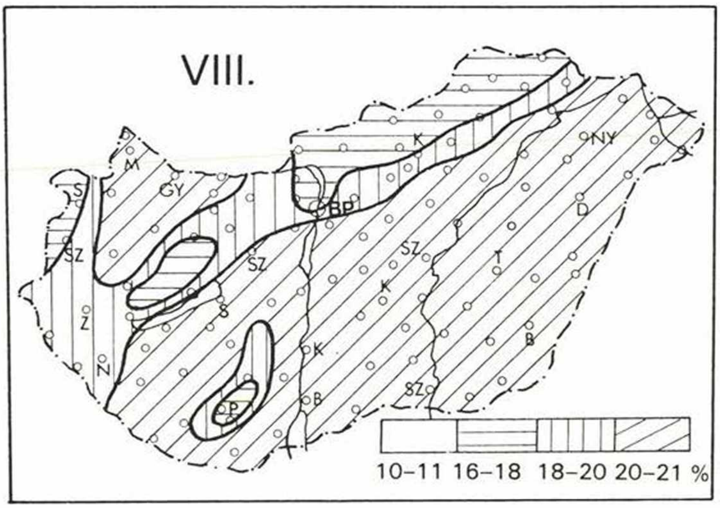

Fig. 10. Areal distribution of the albedo in August (after Weingartner)

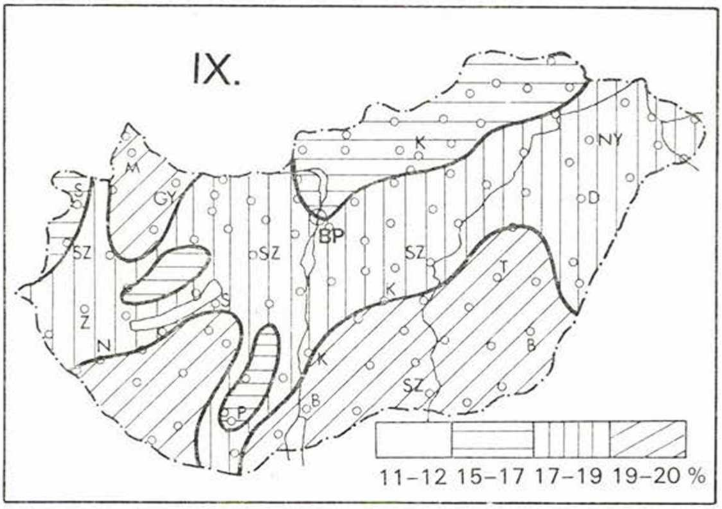

Fig. 11. Areal distribution of the albedo in September (after Weingartner)

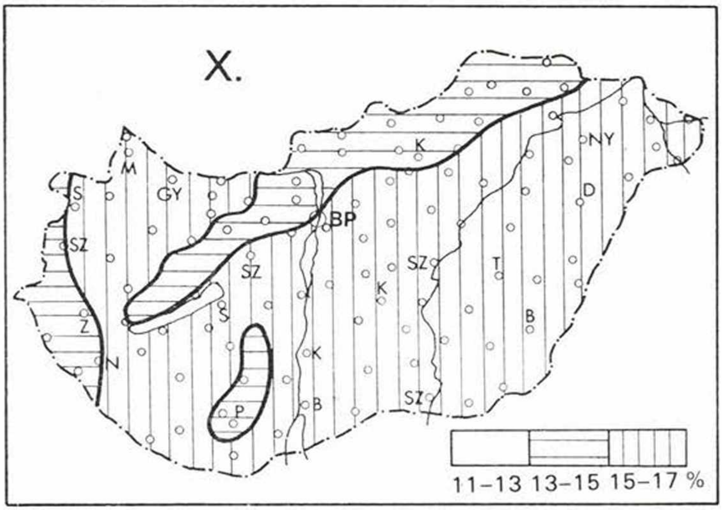

Fig. 12. Areal distribution of the albedo in October (after Weingartner)

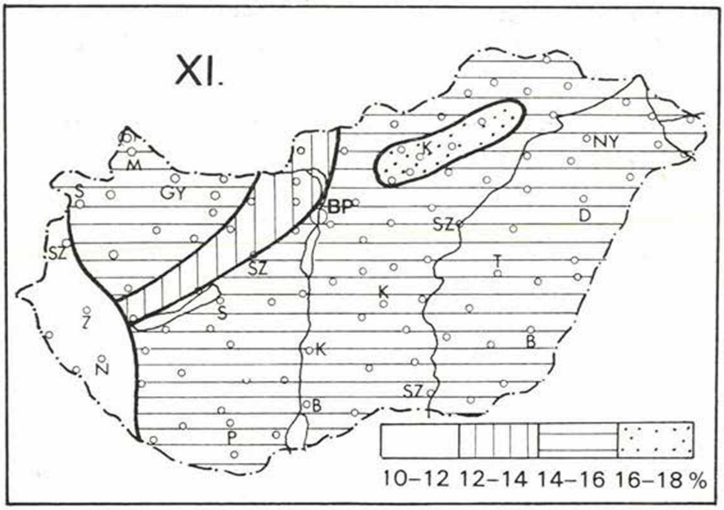

Fig. 13. Areal distribution of the albedo in November

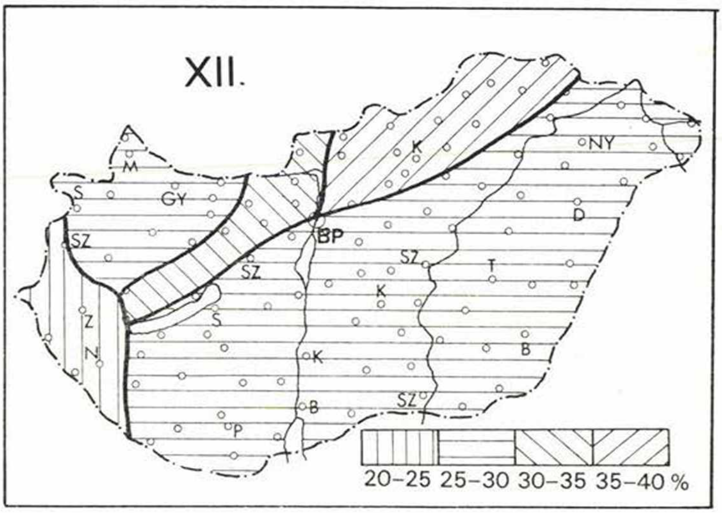

Fig. 14. Areal distribution of the albedo in December

For the preparation of albedo maps of the winter months we used the following albedo data [Zubenok 1949, Davies 1965, Tárkányi 1959, Baroskova et al. 1961, Goll 1964]:

Pine forest	12 – 2%	Zubenok
Beech-tree, oak without foliage	9%	Dirnhirm
Brown field soil, dry	17%	Dobosi
Brown field soil, wet	12%	Dobosi
Sand (Kecskemét)	18%	Tárkányi
Balaton	10%	Weingartner
Snow cover	60%	
Dry grass	21%	Tárkányi
Winter wheat (5 cm) with wet soil	14%	Dobosi
Winter wheat (5 cm) with dry soil	19%	Dobosi

The albedo maps constructed by averaging the albedo values on the basis of their frequencies are shown on the Figures 3 – 14.

REFERENCES

Ádámi Koflanovics, E. (1970): Frequency distribution of the states of ground in Hungary (Manuscript).

Baroskova – Gajevszkij – Djacsenko – Lugina Pivovarova (1961): Radiacionnüj rezsim territorii SZSZSZR. (In Russian) Leningrád.

Borhidi, A. and Dobosi, Z. (1967): Areal distribution of the surface albedo in Hungary. Időjárás 71. pp.: 150 – 157. Budapest.

Davies, J. A. (1965): Albedo investigations in Labrador Ungava. Archiv für Met., Geoph. und Bioklim. Band 13.

Dobosi, Z. (1961): Remarks on the climatological use of the albedo. Időjárás 65. pp.: 364 – 366. Budapest.

Goll, Gy. (1964): The increase of albedo presenting itself on freezing soil. Időjárás 68., p. 112 – 117.

Péczely, Gy. (1966): Frequencies of snow cover in Hungary. Climate of Hungary. Off. Publ. of the State Meteorological Institute Budapest.

Tárkányi, Zs. (1959): Albedo measurements on the Lake Balaton Időjárás 63., p. 100 – 102.

Weingartner, F. (1968): The albedo of various surfaces and plant stocks. Reports on the scientific investigations made in 1967. Off. Publ. of the State Meteorological Institute XXXIV. Budapest.

Weingartner, F. (1970): Areal distribution of the albedo in Hungary. Reports on the scientific investigations made in 1968. Off. Publ. of the State Meteorological Service XXXV. Budapest.

Zubenok, L. I. (1949): Izmerenie albedo pokrovov sz szamoleta. Trudü GGO 18/80 (In Russian.) Leningrád.